DOCUMENT RESUME

ED 300 608 CE 051 250

TITLE	Plasma Cutting and Carbon-Arc Cutting. Welding Module 8. Instructor's Guide.
INSTITUTION	Missouri Univ., Columbia. Instructional Materials Lab.
PUB DATE	88
NOTE	38p.; Printed on variously colored paper. For related modules, see CE 051 243-249.
AVAILABLE FROM	Instructional Materials Laboratory, 10 London Hall, University of Missouri, Columbia, MO 65211.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Behavioral Objectives; Competency Based Education; *Equipment Utilization; Learning Activities; Learning Modules; Lesson Plans; *Metal Working; Secondary Education; *Trade and Industrial Education; *Welding

ABSTRACT

This guide is intended to assist vocational educators in teaching the two units of a module in operating plasma cutting and carbon-arc cutting equipment. The module is part of a welding curriculum that has been designed to be totally integrated with Missouri's Vocational Instruction Management System. The materials included in the module have been formatted for competency-based teaching and testing. All information sheets, transparency masters, job sheets, assignment sheets, and test items are keyed to specific competencies, and a cross-reference table has been included to aid in identifying the parts of the curriculum that relate to specific competencies. Unit tests to evaluate specific competencies have also been provided. (MN)

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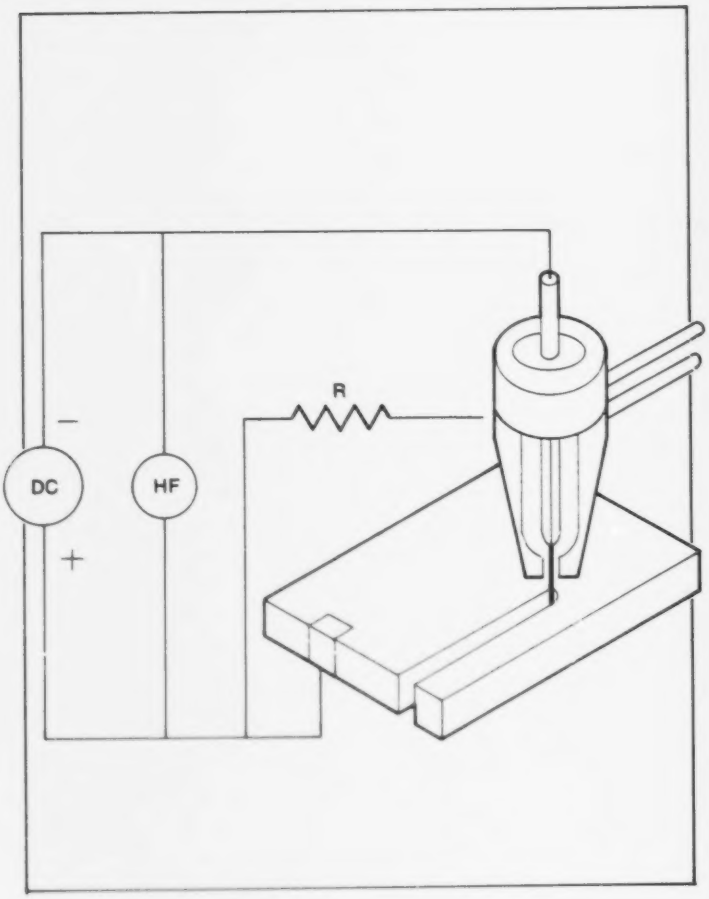
Instructor's Guide

ELDING • Module 8

Plasma Cutting and Carbon-Arc Cutting



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Module: Plasma Cutting and Carbon-Arc Cutting

Cross-Reference Table of Instructional Materials

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
K1	I 1.1				I 2.8		
K2	I 2.1a				I 2.1		
K3	I 2.1c				I 2.3		
K4					I 2.7		
K5	I 2.1d				I 2.4, 2.5		
K6	I 1.2, 2.1e			I 2.1	I 2.6		
K7	I 2.1f				I 2.8		
K8	I 2.1b				I 2.2		
K9					I 2.1		
M1					II 2.1	II 21	
M2	II 1.2-2.3				II 2.1	II 1-20	
M3	II 2.4				II 2.1		

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MODULE: PLASMA CUTTING AND CARBON-ARC CUTTING

UNIT I: PLASMA CUTTING

UNIT OBJECTIVES

Upon completion of this unit, the student should be able to set up and operate plasma cutting equipment, cut square and round solid stock, make straight-line and circular cuts, make pattern cuts on plates and make bevel cuts on plate and pipe. This knowledge will be evidenced by completion of job sheets to specified score.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student will be able to:

1.1 Practice plasma cutting safety rules.

1.2 Utilize guidelines for making pattern cuts.

2.1 Demonstrate the ability to:

a. Set up and operate plasma cutting equipment.*

b. Cut square and round solid stock.*

c. Make straight-line cuts.*

d. Make circular cuts using a guide and free-handed.*

e. Make pattern cuts on nonferrous metal.*

f. Make bevel cuts on pipe.

*Addresses competency listed on profile

MODULE: PLASMA CUTTING AND CARBON-ARC CUTTING

UNIT I: PLASMA CUTTING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: SAFETY AND THEORY

   a. Information outline

   b. Transparency masters

      TM 1.1: Schematic diagram of plasma arc cutting
      TM 1.2: Plasma cutting nozzles

2. Lesson 2: CUTTING

   a. Assignment sheet

      AS 2.1: Pattern for plasma cutting

   b. Job sheets

      JS 2.1: Set up and operate plasma cutting equipment
      JS 2.2: Cut solid stock to specification
      JS 2.3: Straight-line cuts
      JS 2.4: Circle cutting with guide
      JS 2.5: Circle cutting free-handed
      JS 2.6: Making pattern cuts
      JS 2.7: Make bevel cut on plate
      JS 2.8: Make bevel cut on pipe

REFERENCES

A. Books

1. Sacks, J. Raymond. Welding Principles and Practices. Peoria, Ill.: Charles A. Bennett Co., Inc., 1976.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Because of the vast differences in plasma machines, no specifications for exact pressure, gases and operating procedures are given. Adapt the lesson plan for your particular machine.

2. If you prefer that students do not disassemble and reassemble torch completely, go through the steps for the students' benefits so they are familiar with procedures and cautions.

3. Notes on Assignment Sheet 2.1 (to be used with JS 2.6)

   a. Previous cut should have been made with approximately 27 individual cuts.

   b. Lay center piece on table and outer piece over center (just the way they were laid out).

   c. Inspect for excessive cutting, areas where trimming took place (large gaps) and slag left from cutting.

   d. Make a sheet metal template for checking accuracy. Also, a sheet metal template can be used by students to trace out pattern.

4. Although plasma cutting uses different gases than some other processes, guidelines for safely handling cylinders are the same. If the instructor deems necessary, the student should review information in previous units to fulfill competency K9.

B. Suggested student activities

1. All students should learn how to replace electrodes and nozzles. Demonstrate taking the torch apart and have students put it back together correctly.

MODULE: PLASMA CUTTING AND CARBON-ARC CUTTING

UNIT I: PLASMA CUTTING

LESSON 1: SAFETY AND THEORY

I. Plasma is the fourth state of matter. The others are solid, liquid and gas. Plasma cutting requires a **latent heat** (the quantity of heat released by a substance undergoing a change of state, such as water to steam). (TM 1.1)

A. To change from gas to plasma

B. Supplied by electric field in torch

C. DC machine with minimum of 100 volts open circuit voltage (O.C.V.)

D. Regulators control cutting gases exiting torch ports (from 30-350 cu. ft. per hour).

E. Cutting gases

1. Dry, compressed air
2. Nitrogen
3. Carbon dioxide
4. Argon
5. Hydrogen

NOTE: Gas type and amounts change with manufacturer and for type of material to be cut. For specific information, see applicable machine manual.

F. Some plasma machines have high-frequency starting.

II. Plasma cutting safety

A. Follow <u>all</u> safety procedures outlined in all arc welding safety lessons.

B. Leather gloves are particularly <u>important</u>.

CAUTION: Gloves should be in good working condition with no holes. Because plasma can cut anything that conducts electricity, extremities can be severely burned or cut off by the plasma stream.

C. <u>Never</u> allow the plasma operator (or observers) to come into contact with the ground clamp or any pieces contacting the group clamp--including any piece the clamp is on, the table or any electrically conductive material touching the table.

III. Making pattern cuts

A. Pattern cuts are made from joining basic geometric shapes.

1. Squares or rectangles

2. Circles

3. Triangles

4. Ovals

B. Each section of the pattern can be cut independently of the others (requiring many cuts) or cut all in one action (start to finish, non-stop).

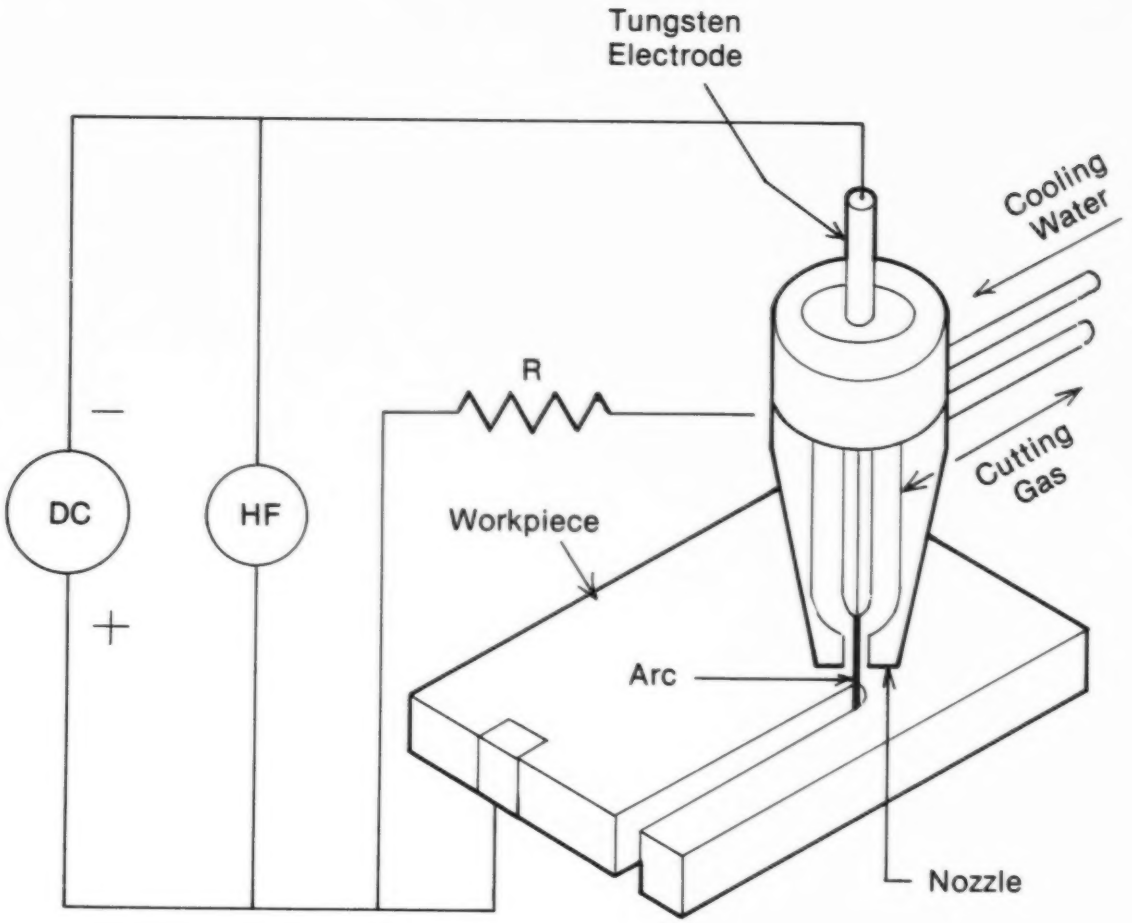
C. Cutting should be done carefully to avoid the following.

1. Overcutting (making the piece too large)

2. Undercutting (making the piece too small)

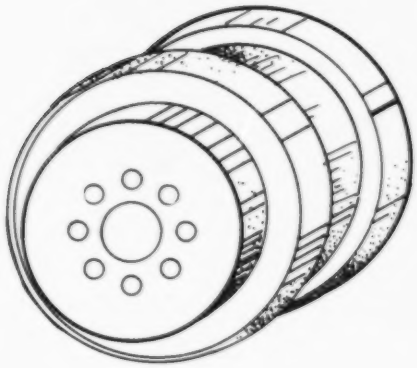
3. Warpage (from excessive heat in one confined area of the pattern)

SCHEMATIC OF PLASMA ARC CUTTING

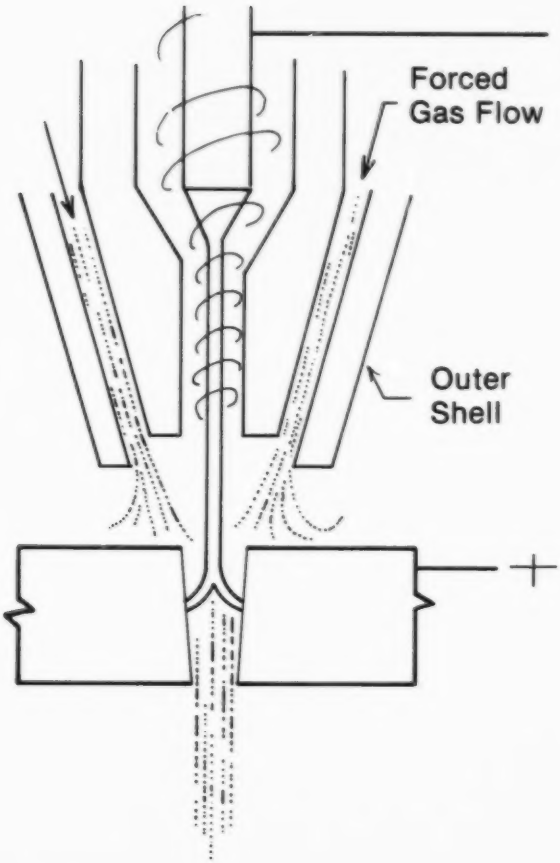


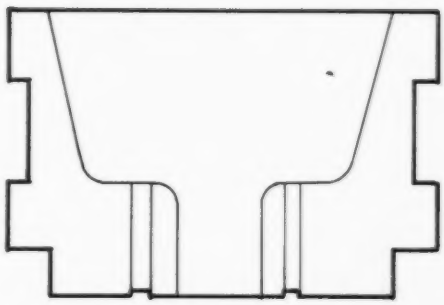
PLASMA CUTTING NOZZLES

Multiport plasma arc cutting nozzle

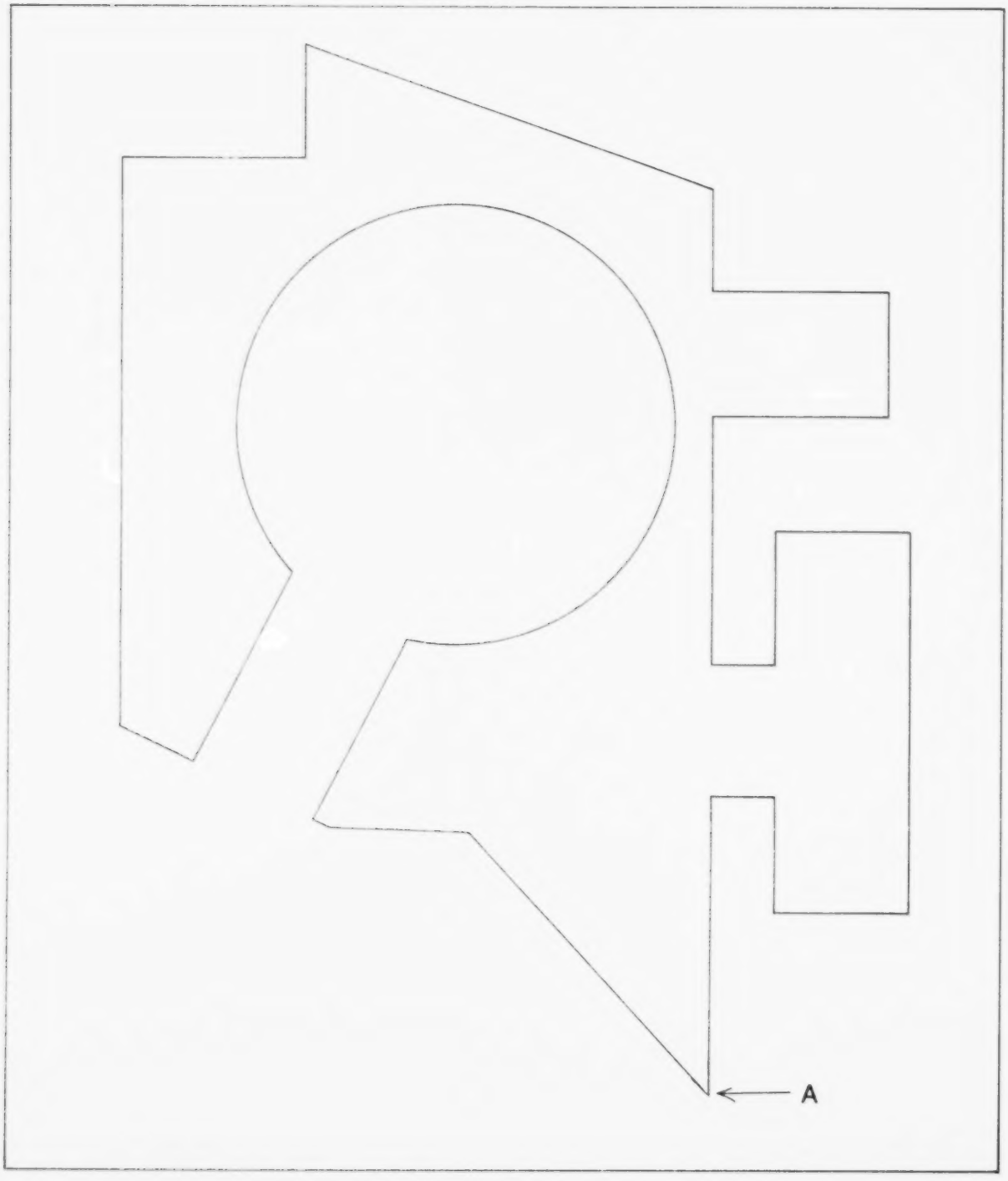


Dual flow plasma arc cutting nozzle





PATTERN FOR PLASMA CUTTING



SET UP AND OPERATE PLASMA CUTTING EQUIPMENT

Equipment:

All safety equipment
Plasma power sources
Plasma torch and leads
Gases (as required by manufacturer)
Ferrous or non-ferrous material

Procedure:	Evaluation 3 2 1 N
1. Connect torch to power source. Attach gas lines from machine to required cylinder or gas line.	— — — —
NOTE: Some machines operate on compressed air while others require gases stored in cylinders or bulk storage tanks.	
2. Set power level on machine to required level. Set regulators or flow meter to required amount for exercise.	— — — —
3. Turn machine on and bleed lines to torch to fill lines with gas.	— — — —
4. If applicable, attach torch coolant lines to water or radiator sources.	— — — —
Average of above evaluations*	— — — —

*This average is the student's final evaluation for competencies K2 and K9.

CUT SOLID STOCK TO SPECIFICATION

Equipment:

Plasma cutting equipment
Safety equipment.
Square and round non-ferrous metal, as approved by instructor
Steel tape
Marking device

Procedure:

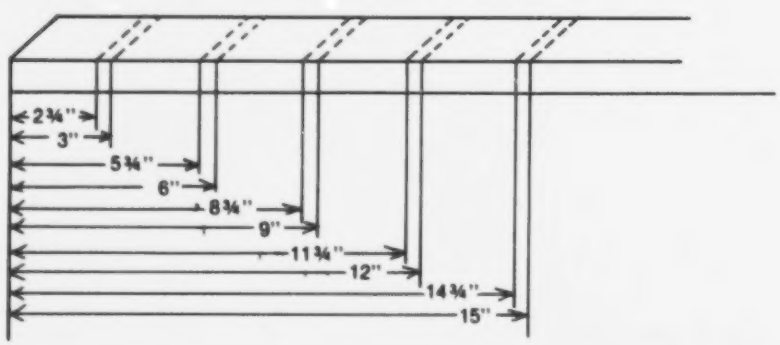
Evaluation
3 2 1 N

1. Activate plasma cutting machine, set amperage, regulate as per instructor's directions. — — — —

2. Using steel tape, mark the solid stock 2 3/4" from the end. Also mark at 3" from the end. — — — —

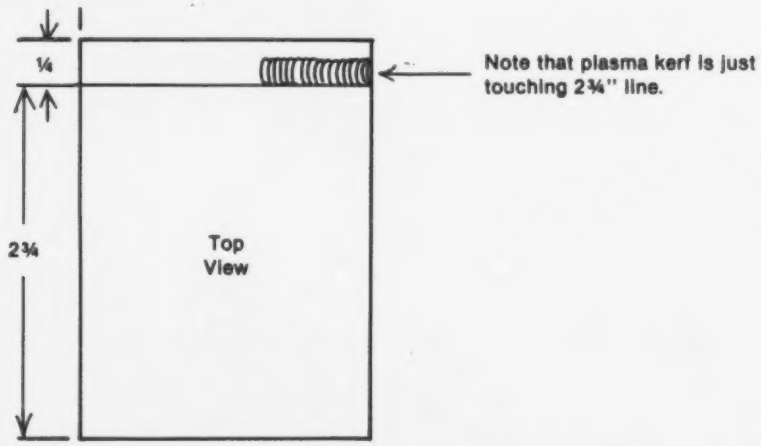
   NOTE: To cut metal pieces with precision, a length of stock must be left to compensate for kerf width. If you simply mark the solid stock off in 2 3/4" increments, the kerf width will have to be subtracted from the length when the plasma cut is made. This will cause a too-short length and possibly render it useless to the employer. Kerf width cannot be measured accurately in a cut because the kerf width increases as travel speed slows. It is better to allow for a little waste material to ensure exact product sizing than to produce an unusable product.

3. Continue this procedure until five 2 3/4" pieces are marked out. — — — —



4. Bring plasma torch up to cutting area. Lower welding helmet and proceed to cut solid stock. — — — —

5. Note position of cutting stream. Stay just to the inside of the lines previously marked 1/4" apart. — — — —



6. Once finished with the cut, readjust or reposition your hand so that the next line can be cut accurately. Cut the 3" line off of the solid stock. This will take the stock to a true starting point. — — — —

7. Continue the above procedure until the five pieces have been cut. Shut down plasma machine. Water or air cool the five metal pieces cut in this exercise. — — — —

8. Ask instructor check your work. — — — —

9. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competency K8: Lay out and cut square and round solid stock on nonferrous metal.

STRAIGHT-LINE CUTS

Equipment:

Plasma cutting equipment
Safety equipment
Non-ferrous metal, as approved by instructor
Straight-edge (angle iron, channel or square tubing, etc.)

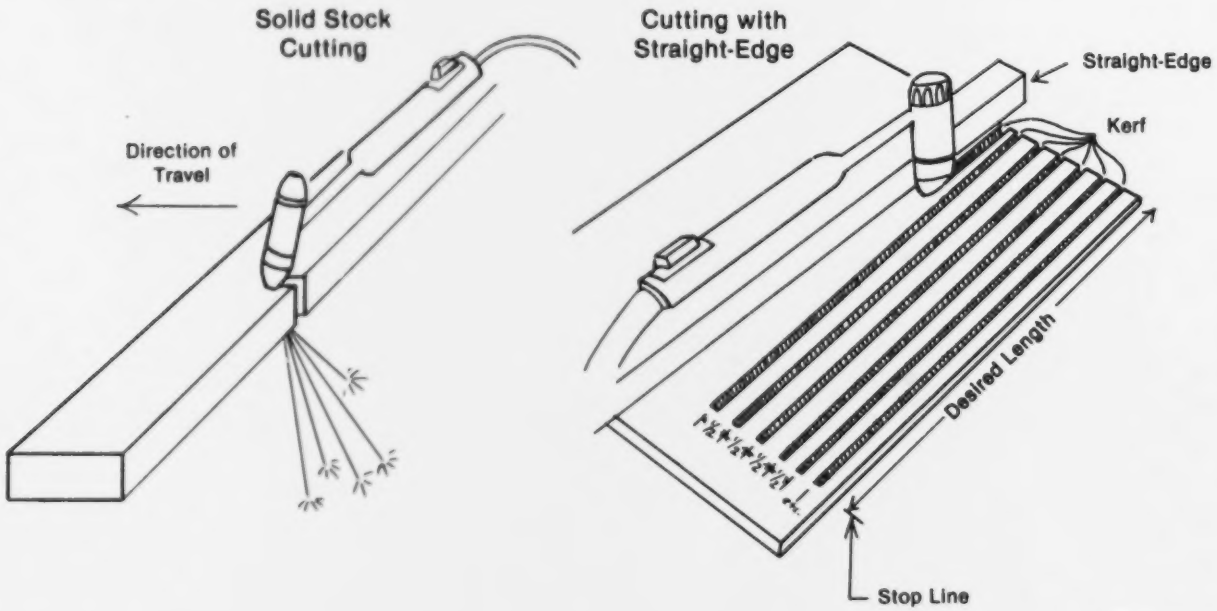
Procedure:

Evaluation
3 2 1 N

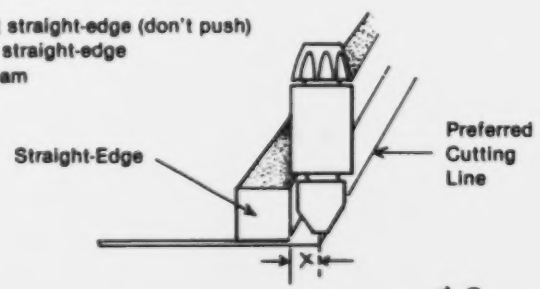
1. Activate plasma machine, set amperage, regulate per instructor's directions. — — — —

2. Using straight-edge, mark lines on material to be cut. Align straight-edge with mark so kerf of plasma cutting will remove (cut out) line. — — — —

3. Start machine and move along side of straight-edge for complete length of desired cut. — — — —



Note: Rest torch against straight-edge (don't push)
x = Distance from straight-edge to cutting stream



4. Stop cutting action and place plasma torch in safe location. Check work for slag, burn-through and accuracy. — — — —

5. Ask instructor to check your work. — — — —

6. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competency K3: Lay out and make straight-line cuts on nonferrous metal.

CIRCLE CUTTING WITH GUIDE

Equipment:

Plasma cutting equipment
Safety equipment
Non-ferrous metal, as approved by instructor
Circle-cutting attachment

Procedure:	Evaluation 3 2 1 N
1. Activate plasma cutting machine, set voltage, regulate per instructor's directions.	— — — —
2. Cut with mechanical guide.	— — — —
a. Attach circle cutting attachment as manufacturer recommends.	
b. Center punch center of circle. Adjust pivot pin on cutting attachment for desired radius of circle.	
c. Check work area to be sure cable and hoses are clear and free of any obstacles that would interfere with cutting path.	
d. Run the torch through the motions of making a circular cut to ensure smooth operation.	
e. With safety gear in place, make circle cut.	
NOTE: It's easier to dry walk a cut through and adjust <u>before</u> a cut is made than to grind or file the hole out because the center is gone.	
3. Ask instructor to check your work.	— — — —
4. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	— — — —
Average of above evaluations*	— — — —

*This average is the student's partial evaluation for competency K5: Lay out and make circular cuts on nonferrous metal.

CIRCLE CUTTING FREE-HANDED

Equipment:

Plasma cutting equipment
Safety equipment
Non-ferrous metal, as approved by instructor

Procedure:

Evaluation 3 2 1 N

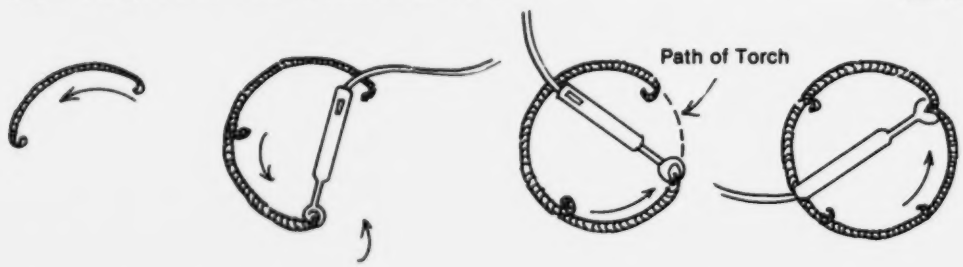
1. Draw, trace or use compass to make mark for desired size circle to be cut. — — — —

2. Small circles (3" diameter or less) can be cut in one circular movement. Pierce hole and continue cut so plasma stream takes out line on metal. — — — —

3. Large circles (3" or larger in diameter) can be performed with greater ease if cut in small arcs. Pierce hole on inside of circular line (if plate is to be saved) or outside of circular line (if circle is to be saved). — — — —

4. Continue the cut until you get uncomfortable (may not be able to control the torch with ease). When the end of an arc is near, swing the cutting stream in or out of line (depending on whether circle is scrap or a good piece). — — — —

5. Reposition yourself and the torch to continue cut. — — — —



6. Ask instructor to check your work. — — — —

7. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competency K5: Lay out and make circular cuts on nonferrous metal.

MAKING PATTERN CUTS

Equipment:

Plasma arc cutting machine
All personal safety clothing and equipment
Marking device suitable for non-ferrous base metal
Print as specified by instructor

INSTRUCTOR'S NOTE: AS 2.1 can be used with this job sheet as a pattern.

Procedure:	Evaluation 3 2 1 N
1. Lay out pattern on sheet of metal as indicated by instructor.	— — — —
a. If using AS 2.1 as pattern, start at point A and proceed around pattern in a clockwise direction.	
b. Cut straight lines and circle either free-handed or by guide, as per instructor.	
c. The inner piece is the piece to be saved. However, there are two pieces to be turned in: the inner, cut to specifications, and the outer, left in one piece with the same outer dimensions as when the job was started.	
d. All piercing is to take place on the outer piece with no excessive cuts.	
2. Activate plasma machine and make necessary adjustments to current and gas flow. Place sheet with pattern drawn on cutting table.	— — — —
3. Use scrap piece of sheet (identical type to piece pattern is drawn on) for practice cut.	— — — —
4. Readjust machine if needed and test again until desired cut is achieved.	— — — —
5. Ask instructor to check your work.	— — — —
6. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	— — — —
Average of above evaluations*	— — — —

*This average is the student's final evaluation for competency K6: Lay out and make pattern cuts on nonferrous metal.

MAKE BEVEL CUT ON PLATE

Equipment:

Plasma arc cutting machine
All personal safety clothing and equipment
Nonferrous metal, as approved by instructor
Straight-edge

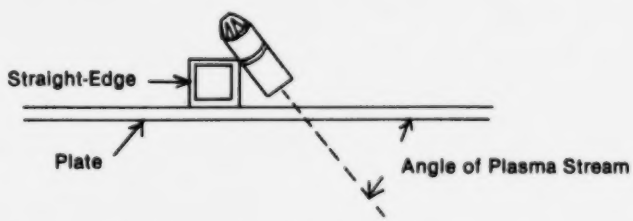
Procedure:

Evaluation
3 2 1 N

1. Activate plasma machine. Set regulators to desired pressure. Place metal on cutting table. — — — —

2. Make practice cut and readjust if necessary. — — — —

3. Lay straight-edge on metal plate. Lay torch so ceramic tip rests on plate and side of torch head is against straight-edge with torch at an angle other than 90 degrees to plate. — — — —



4. Move torch entire length of cut to eliminate binding or catching of leads. Lower head and make cut the entire length of plate. — — — —

5. Rotate plate 90 degrees and follow previous procedure again. — — — —

6. Ask instructor to check your work. — — — —

7. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competency K4: Lay out and make bevel cuts on nonferrous metal.

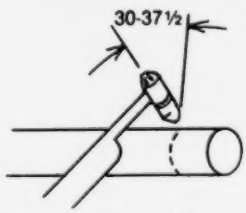
MAKE BEVEL CUTS ON PIPE

Equipment:

Plasma arc cutting machine
All personal safety clothing and equipment
Pipe as specified by instructor
Wraparound or other marker

Procedure:

		Evaluation 3 2 1 N
1.	Activate plasma machine. Set regulator(s) to desired pressure. Place pipe on work table.	— — — —
2.	Using pipe wraparound or mechanical pipe circumference marking tool, mark a line two inches from end of pipe.	— — — —
3.	Place pipe on cutting table and put on all safety equipment. Make practice cut on metal the same thickness as pipe wall.	— — — —
4.	Make adjustments to amperage and/or gas if needed. Place plasma torch so a bevel of 30-37 1/2 degrees can be achieved.	— — — —



5.	Pierce through the pipe wall away from the 2" mark and move toward marked line.	— — — —
6.	Move to line then proceed around pipe, starting and stopping as few times as possible. Keep the torch at an angle of 30-37 1/2 degrees perpendicular to the pipe wall.	— — — —
7.	When the cut has reached the limit of your comfort, use swing-out technique as previously outlined.	— — — —
8.	Restart cut after repositioning pipe or yourself. Move to line and proceed around pipe. Continue procedure until pipe is cut.	— — — —
9.	Ask instructor to check your work.	— — — —
10.	As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	— — — —
	Average of above evaluations*	— — — —

*This average is the student's final evaluation for competencies K1 and K7.

MODULE: PLASMA CUTTING AND CARBON-ARC CUTTING

UNIT II: CARBON-ARC CUTTING

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify necessary equipment and electrodes and should safely demonstrate the carbon-arc cutting process (also referred to as air carbon-arc cutting). This knowledge will be evidenced by completion of job sheets to specified score.

SPECIFIC OBJECTIVES

1.1 Complete statements concerning principles of carbon-arc cutting (CAC).

1.2 Identify equipment needed for CAC.

1.3 Complete statements concerning CAC power sources.

1.4 Match types of CAC electrodes with their characteristics.

1.5 Complete statements concerning CAC electrode shapes and uses.

2.1 Match CAC electrode angles with their uses.

2.2 Select true statements concerning amperage selection for gouging.

2.3 Complete statements concerning adjustment effects on gouging.

2.4 Cut mild steel with CAC.*

*Addresses competencies on profile

MODULE: PLASMA CUTTING AND CARBON-ARC CUTTING

UNIT II: CARBON-ARC CUTTING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: EQUIPMENT AND MATERIALS

   a. Information outline

2. Lesson 2: TECHNIQUES

   a. Information outline

   b. Job sheet

      JS 2.1: Cut mild steel with CAC

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. The Metal Craftsman's Handbook. Athens, Geo.: American Association for Vocational Instructional Materials, 1980.

B. Curriculum guide

1. Fortney, Clarence, and Mike Gregory. Shielded Metal Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Make sure safety is stressed and the cutting area is safe from flying sparks. Ear plugs should be used during prolonged activity.

2. Steadiness of hand is very important. Students should practice making grooves, cutting metal and removing weld from joints.

B. Suggested supplemental materials

1. Welding manufacturer reference sheets

MODULE: PLASMA CUTTING AND CARBON-ARC CUTTING

UNIT II: CARBON-ARC CUTTING

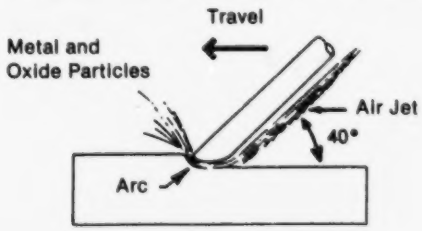
LESSON 1: EQUIPMENT AND MATERIALS

I. Principles of carbon-arc cutting (CAC)

A. CAC is a cutting process that cuts or gouges metal by using an electric arc between a carbon electrode and a base metal.

B. No filler metal or shielding gas is used in carbon-arc cutting.

C. As the arc melts the base metal, a controlled stream of compressed air is directed at the arc to remove molten metal to make a complete cut or produce a groove.



D. The process was patented in 1885 in England.

II. Equipment for CAC

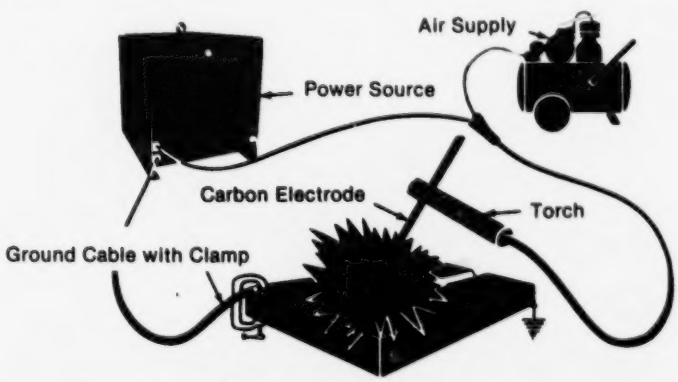
A. Power supply

B. Air supply

C. Carbon electrodes

D. Air carbon-arc torch

E. Ground cable with clamp



Credit: L-TEC Welding & Cutting Systems, Florence, S. Carolina

III. CAC power sources

A. Standard power sources for arc welding can be used for CAC, but an open-circuit voltage of at least 60V is needed.

1. Variable-voltage motor-generator, rectifier or resistor-grid equipment (DC) is recommended for all electrode sizes.

2. Constant-voltage motor-generator or rectifier (DC) is recommended only for electrodes above 1/4" in diameter.

3. AC transformers should be used only with AC electrodes.

4. AC-DC rectifiers

a. DC supplied by three-phase transformer-rectifier is satisfactory. DC from single-phase source is not recommended.

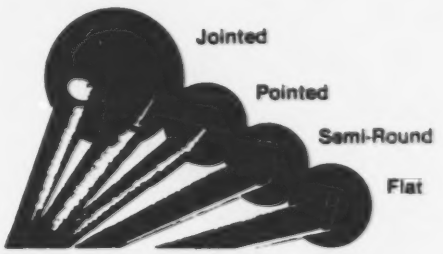
b. AC from AC-DC power source is satisfactory if AC electrodes are used.

B. Air pressure required to make a cut depends on the diameter of the carbon electrode. Air pressures usually range from 40-80 psi.

CAUTION: Be careful when draining moisture from an air line.

Max. electrode size (in.)	Application	Pressure (psi)	Consumption (cfm)
1/4	Intermittent-duty, manual torch	40	3
1/4	Intermittent-duty, manual torch	60	9
3/8	General-purpose	60	16
3/4	Heavy-duty	60	29
5/8	Semiautomatic mechanized torch	60	25

IV. Characteristics and types of CAC electrodes



A. Copper-coated electrodes are made of graphite (carbon) for DC operation in sizes from 5/32" to 1."

B. Flux-coated steel electrodes are used for cutting or gouging high-purity copper or cast iron (1/4" in diameter and 18" in length).

C. Graphite electrodes have no copper coating, which tends to make the electrode "pencil," causing a gradual decrease in the groove's size.

V. CAC electrode shapes and uses

A. A round electrode is used to gouge a U groove.

B. A semi-round electrode can also be used to gouge a U groove.

C. A semi-round electrode can also be turned to gouge a flat groove.

D. A flat electrode is used to make a flat groove.

MODULE: PLASMA CUTTING AND CARBON-ARC CUTTING

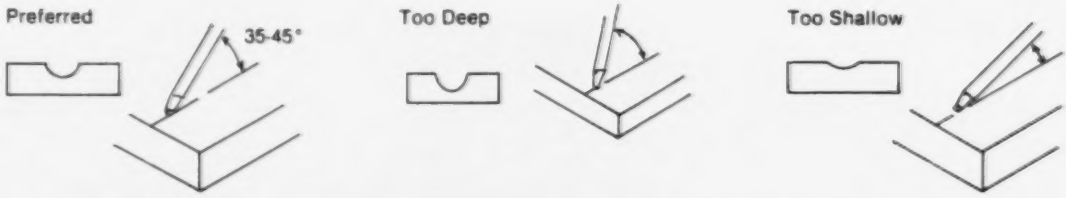
UNIT II: CARBON-ARC CUTTING

LESSON 2: TECHNIQUES

I. CAC electrode angles and uses

NOTE: Illustrations are courtesy of Union Carbide Corporation, Linde Division.

A. An angle of 35-45 degrees between electrode and work is the preferred angle for gouging.



B. A higher angle (more than 45 degrees) is discouraged because it causes the groove to cut deeper into the base metal, impairing metal removal.

C. A flatter angle (less than 35 degrees) is not preferred since it causes shallow grooving in the base metal.

II. Amperage selection for gouging

A. Amperage should be selected according to power source and electrode size.

Type of electrode and power	Maximum and minimum current (amp) Electrode size (in.)					
	5/32	3/16	1/4	5/16	3/8	1/2
DC electrodes, DCRP power	90-150	150-200	200-400	250-450	350-600	600-1000
AC electrodes, AC power	---	150-200	200-300	---	300-500	400-600
DC electrodes, DCSP power*	---	150-180	200-250	---	300-400	400-500

*Materials affected by carbon (nickel and monel)

B. When amperage is lower than recommended, the groove will retain a U shape but will be shallow.

C. When amperage is higher approximately 25% higher than recommended, the groove will change from a U to a V shape.

D. When amperage is set as recommended, the groove will have a uniform U shape with good depth.

III. Adjustment effects on gouging

A. Air pressure

1. Low air pressure tends to produce an irregular surface and edge.

2. Correct air pressure allows for slag-free cuts.

B. Travel speed

1. Slow travel speed generates more heat input into the base metal and produces a deeper groove.

2. High travel speed decreases metal removal.

3. Correct travel speed produces a groove depth that is approximately half the diameter of the electrode.

IV. Procedures and techniques for gouging

A. Vertical gouging should be done in the downhill direction (vertical down) to allow for safe removal of molten metal.

B. Horizontal gouging may be done left or right, but the airstream must remain behind the electrode with respect to the direction of travel.

C. With overhead gouging, the electrode should be perpendicular to the base metal and angled so that molten metal will not drop on the operator.

D. Always keep the air stream behind the carbon electrode in the direction of travel.

CUT MILD STEEL WITH CAC

Equipment:

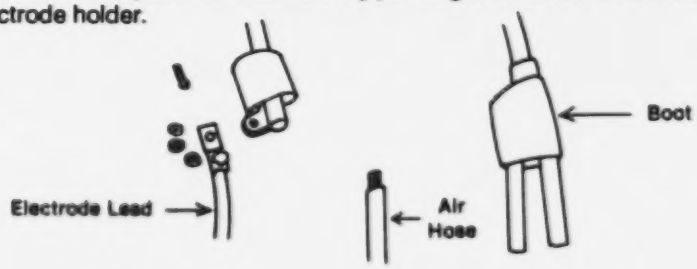
Personal arc welding safety clothing and equipment
Arc welder
Air carbon-arc electrode holder
Air carbon-arc cutting electrode
Compressed air supply with regulator
Air hose
Chipping hammer
Mild steel plate, as approved by instructor

Procedure:

Evaluation
3 2 1 N

1. Check area to make sure it is free of flammable materials and is well-ventilated. Note the location of the nearest fire extinguisher. — — — —

2. Expose air and power connections by pushing back insulated boot on CAC electrode holder. — — — —



3. Attach electrode holder to power cable assembly. Attach air hose to air hose connection and replace insulated boot over air and power connections. — — — —

4. Attach regulator to compressed air supply and attach air hose to regulator. — — — —

   CAUTION: Do not use oxygen as the compressed air supply (flammable).

5. Adjust regulator to 60-100 psi; spray air on a piece of metal to make sure it is moisture-free. — — — —

   NOTE: If moisture collects on the metal, compressed air should be checked.

6. Select a standard carbon electrode that will function best with DC+ polarity. Adjust amperage according to electrode diameter. — — — —

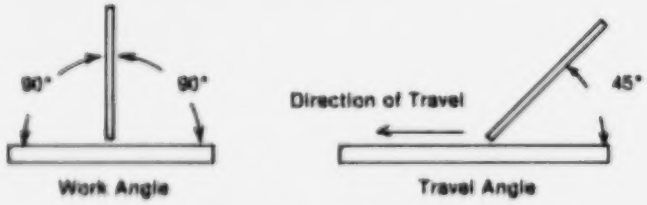
ELECTRODE SIZE in.	mm	COPPER COATED DC TYPES (Reverse Polarity) Amps		AC TYPES Amps	GROOVE WIDTH (Approximate) in.	mm
5/32	4	90-200		—	3/16	5
3/16	5	150-250		200-250	1/4	6
1/4	6	250-400		300-400	5/16	8
5/16	8	300-500		325-425	7/16	11
3/8	10	350-600		400-550	1/2	13
1/2	13	600-1000		500-600	5/8	16
5/8	16	800-1250		—	3/4	19
3/4	19	1200-1500		—	7/8	22
Semi-Round		Flat Position	Round Position			
3/8	10	200-375	250-500	—	1/2	13
5/8	16	350-1000	600-1200	—	3/4	19
Flats						
3/8	10	400 (max.)		—	1/2	13
5/8	16	500 (max.)		—	3/4	19

NOTE: DCSP electrodes produce more heat on the base metal than DCRP electrodes detailed above.

7. Attach ground clamp to workpiece. Turn on welding machine. — — — —

8. Place electrode in jaws of electrode holder with no more than 6" of electrode extending in front of the air jets. Don't burn the electrode past the 2" length. — — — —

9. Position air jets between the electrode and metal if the metal is 1/2" thick or less. Position the electrode between the air jets and the base metal if the base metal is more than 1/2" thick. Position electrode angle as indicated. — — — —



10. Turn on air jet with air valve on electrode holder. Strike arc and swing the electrode in and out of the metal without breaking the arc. — — — —

11. Move electrode in the direction of the cut just as the arc first exits the base metal's back side. Continue with a slight swinging motion for the entire length. — — — —

12. Finish cut. Stop. Turn off jet air by using the air valve on the electrode. Place electrode holder in a safe position where it cannot spark. — — — —

13. Ask instructor to check your cut. — — — —

14. Make adjustments, if required, and complete other cuts as directed by instructor. — — — —

15. Turn off air supply and welding machine. Remove CAC electrode holder from air hose. Clean up area and return tools and materials. _____

Average of above evaluations* _____

*This average is the student's final evaluation for competencies M1-3.

MODULE: PLASMA CUTTING AND CARBON-ARC CUTTING

UNIT II: CARBON-ARC CUTTING

UNIT TEST

Choose the option which best answers the question or completes the statement.

___ 1. How does CAC differ from other welding processes?

a. Uses no filler metal or shielding gas
b. Uses compressed nitrogen
c. Uses special fillers
d. Uses carbon electrode and filler

___ 2. Standard power sources for arc welding can be used for CAC, but an open-circuit voltage of at least _____ is needed.

a. 20V
b. 40V
c. 60V
d. 80V

___ 3. Air pressure required to make a cut depends on the _____ of the electrode. Pressures usually range from a minimum of ___ psi.

a. Shape, 40-80
b. Diameter, 30-60
c. Shape, 30-60
d. Diameter, 40-80

___ 4. Which type of CAC electrode causes a gradual decrease in the size of a groove?

a. Flux-coated steel
b. Graphite
c. Copper coated
d. Carbonated

___ 5. Which type of electrode is used for cutting high-purity copper or cast iron and is available with a 1/4" diameter and 18" length?

a. Flux-coated steel
b. Graphite
c. Copper coated
d. Carbonated

___ 6. Which type of electrode is used to gouge a U groove?

a. Round
b. Semi-round
c. Flat
d. All of the above
e. a and b

Identify equipment needed for CAC by placing the appropriate letter in the blank.

___ 7.

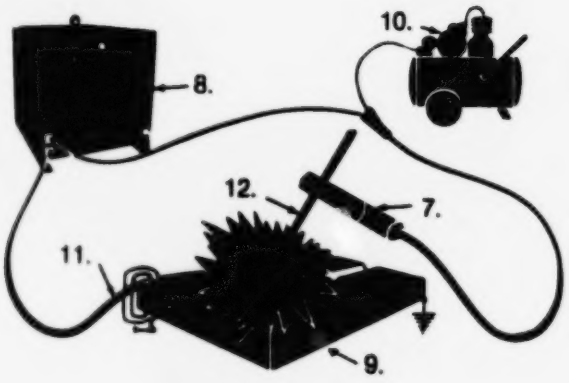
___ 8.

___ 9.

___ 10.

___ 11.

___ 12.



a. Carbon-arc torch
b. Air supply
c. Carbon electrode
d. Ground cable with clamp
e. Power source
ab. Workpiece

Select the option which best answers the question or completes the statement.

___ 13. What is the preferred electrode-to-work angle for gouging?

a. 10-25 degrees
b. 15-30 degrees
c. 35-45 degrees
d. 45-60 degrees

___ 14. Which angle is <u>not</u> preferred for gouging because it causes the groove to be cut deeper in the metal?

a. 10-25 degrees
b. 15-30 degrees
c. 35-45 degrees
d. 45-60 degrees

___ 15. Amperage for gouging should be selected according to _____ .

a. Power source and electrode size
b. Power source only
c. Electrode size only
d. Electrode length

___ 16. What causes a groove to change from a U to V shape?

a. Amperage approximately 25% higher than recommended
b. Amperage 45% higher than recommended
c. Amperage 25% lower than recommended
d. Amperage 40% lower than recommended

___ 17. Which type of gouging should be done in the downhill direction for safe removal of molten metal?

a. Vertical
b. Horizontal
c. Overhead
d. Flat

___ 18. An irregular surface and edge is generally produced by _____ .

a. High air pressure
b. Low amperage
c. Low air pressure
d. High amperage

___ 19. When gouging, slow travel speed generates _____ heat input into the base metal and produces a _____ groove.

a. Less, deeper
b. More, deeper
c. Less, shallower
d. More, shallower

___ 20. Correct travel speed produces a groove depth that is about _____ the diameter of the electrode.

a. Equal to
b. One-half
c. Three-quarter
d. Twice

___ 21. Which technique requires the electrode to be perpendicular to the base metal and angled so that molten metal will not drop on the operator?

a. Vertical
b. Horizontal
c. Flat
d. Overhead

NOTE: Completion of this test to specified score is the student's partial evaluation for competencies M1 and M2.

ANSWERS TO UNIT TEST

1.	a	(M2)
2.	c	(M2)
3.	d	(M2)
4.	b	(M2)
5.	a	(M2)
6.	e	(M2)
7.	a	(M2)
8.	e	(M2)
9.	ab	(M2)
10.	b	(M2)
11.	d	(M2)
12.	c	(M2)
13.	c	(M2)
14.	d	(M2)
15.	a	(M2)
16.	a	(M2)
17.	a	(M2)
18.	c	(M2)
19.	b	(M2)
20.	b	(M2)
21.	d	(M1)

The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.